

Frontier Technologies as an innovative tool to transform Waste to Wealth

Concept Note

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Introduction

World Habitat Day, observed on the first Monday of October each year, supports UN-Habitat's mission towards transformative change in cities and human settlements – to leave no one and no place behind. Building on last year's theme "Municipal Solid Waste Management" UN-Habitat is this year promoting the contribution of innovative frontier technologies to sustainable waste management to achieve Sustainable Development Goal 11: inclusive, safe, resilient and sustainable cities. Going beyond solid waste this includes all waste produced by human activity (solid, liquid, domestic, industrial and commercial), which continues to have a devastating impact on climate change, public health and the environment.

According to the World Economic and Social Survey 2018¹, frontier technologies hold immense potential to improve how people work and live, as well as to significantly accelerate efforts to achieve the Sustainable Development Goals and address climate change. Frontier technologies, such as automation, robotics, electric vehicles, renewable energy technologies, biotechnologies and artificial intelligence (see Box 1 for more examples), can possibly transform the social, economic and environmental spheres. They offer the potential of better, cheaper, faster, scalable and easy to use solutions for every-day problems, including waste management. They also present opportunities for developing countries to leapfrog towards less efficient technologies and implement social innovations. In line with these possibilities, the New Urban Agenda calls for enhanced cooperation and knowledge exchange on science, technology and innovation that will influence the development of current and future urban areas in the world.

Box 1: Examples of frontier technologies²



Big data analysis:
provides real-time streams of information through analyzing sets of huge amounts of data, while facilitating segmentation and targeting within that dataset.



The Internet of Things:
the extension of Internet connectivity to physical devices and everyday objects, thus enabling enhanced monitoring and management.



Sustainable polymers:
plastic materials that address the needs of consumers without damaging the environment, health and economy.



Artificial intelligence:
includes machine learning, automation, problem solving and logical reasoning that could transform production processes and business.



3D printing:
produces objects through a simple process of layering and allows faster and cheaper low-volume production and prototyping of complex products and components.



Nanotechnology:
manufacture and use of materials at an infinitesimal scale, which behave differently than their larger counterparts.



Renewable energy technologies:
including wind, bio and solar energy technologies that have the potential to substantially reduce carbon emissions in energy production.



Drones & small customized satellites:
Other innovative approaches, such as new business models, product-service-systems.

Frontier technologies can create, but also reduce jobs and disrupt existing markets and economies. They present challenges related to privacy, security, transparency and ethics. Thus, the task ahead is to harness frontier technologies to achieve sustainable development, while mitigating their adverse economic, social and political consequences.

Waste challenges

The world's cities produce about 7-10 billion tonnes of waste per year³, and struggle to fulfil basic waste management requirements. Municipalities in low-income countries spend on average 20 per cent of their budgets on solid waste management and under three per cent on sanitation. However, this is, in most settings, not enough to finance basic waste and sanitation management systems, while users are often unable or unwilling to pay for the waste services provided. In effect, solid waste collection reaches less than half of the population in cities in low-income countries, and 16 per cent of urban dwellers lack access to basic sanitation services. Globally, one third of the generated solid waste is still openly dumped, while only one fifth goes to material recovery, i.e. recycling and composting, and 80 per cent of all wastewater is discharged in the world's waterways.⁴

The lack of adequate waste management has resulted in excessive air, soil and water pollution, threatening public health, ecosystems and biodiversity, as well as accumulating immense quantities of waste in the world's oceans – especially as 90 per cent of urban areas are located at coastlines. It is assumed that plastics entering the oceans are killing 100,000 marine animals every year.⁵ This pollution has considerable economic effects on tourism, fisheries and healthcare: about US\$ 375 per metric ton of solid waste.⁶ Furthermore, it is estimated that every 30 seconds a person dies due to diseases caused by mismanaged waste, such as diarrhoea, malaria, heart diseases and cancer – accounting to between 400,000 and one million deaths a year.⁷

The Agenda 2030 for Sustainable Development, particularly Sustainable Development Goals 6, 11, 12 and 14,⁸ as well as the Paris Agreement and the New Urban Agenda, all consider waste management as an urgent and critical issue that must be addressed to ensure the future prosperity and sustainability of our planet.

The lack and inconsistency of global data on waste management and treatment remains a major challenge. The absence of waste flow data in many developing and middle-income countries – how much is generated, collected, by whom, what is recycled and managed in an environmentally sound way or not, and what is going where – hampers the ability to respond with adequate and responsive measures. While waste is considered a local problem, production, consumption and recovery of materials are global mechanisms, leading to the transboundary movement of materials, products and waste.

Waste opportunities

Although often considered a problem, sustainable waste management also presents opportunities. From innovating waste management through rethinking, refusing, reducing, reusing and recycling waste (the "5Rs"), cities can resolve not only the challenge, but also create employment, promote economic growth, improve health and ecosystems – which in turn contributes to happier, greener and healthier cities – and can create enormous savings for cities and municipalities. Water remains one of our most precious resources. Therefore, wastewater can and urgently needs to be safely managed, to respond to the ever-increasing water scarcity and to reduce pollution. Wastewater is an affordable and sustainable source of water, energy, nutrients and other recoverable materials.

Frontier technologies presents important circular economy opportunities for cities and human settlements. They are regenerative by design, retaining as much value as possible over a product's lifetime and can turn waste into wealth. Cities can become pioneers in conserving precious resources, saving energy (see Box 2) and reducing greenhouse gas emissions, thus contributing to combatting climate change. In 2010 the Intergovernmental Panel on Climate Change attributed three percent of global anthropogenic greenhouse gas emissions to waste disposal and wastewater treatment; however, the mitigation potential through adopting sustainable waste management practices including the 5R is estimated at 15-20 per cent of worldwide greenhouse gas emissions.⁹ Cities can protect the oceans from solid and liquid waste pollution, while significantly enhancing the quality of life of their citizens.

Box 2: Energy savings of recycling compared to using raw materials¹⁰



Frontier technologies could also be deployed as part of an integrated urban management system; for example, generating data on waste management that will feed into the data generated on other urban topics as public health, commercial licensing and emergency management.

Innovative approaches to reach sustainable waste management needs to address all areas of the waste hierarchy: reduction, reuse, recycling, recovery and disposal. Reducing waste generation through rethinking, refusing and reusing, e.g. by safely upcycling of waste materials to fashion, jewellery or furniture, or using shower water to flush the toilet, creates the biggest impact. Nevertheless, alternative and locally tailored ways for material and water recycling and recovery e.g. through waste-to-energy such as landfill gas collection, anaerobic digestion and incineration, as well as waste disposal must be found and applied to complete the cycle.

UN-Habitat's response

On World Habitat Day 2018, the **Waste Wise Cities Campaign** was launched to raise awareness on municipal solid waste management challenges and initiate activities, with a call to action for integrated sustainable waste management in the world's cities. It reaches out to local governments and promotes twelve principles that include the "Integrated Sustainable Waste Management Framework", for example improved collection and treatment of waste, as well as stakeholder involvement. The Campaign highlights the need for cities to consider all aspects of sustainable waste management as well as innovative approaches, if they want to turn waste into wealth and move towards a circular economy.

Innovation is fundamental to how UN-Habitat does business today – as demonstrated by the first UN-Habitat Assembly which took place in May 2019, with the theme "Innovation for Better Quality of Life in Cities and Communities". The theme was debated and discussed from all urbanization angles during the week, from the grassroots to the highest policy-making level, and was demonstrated through an Urban Innovation Exhibition which presented innovative approaches to urban challenges.

Previous winners of UN-Habitat's Best Practice Award and UN-Habitat Scroll of Honour award have had innovation at the centre of their projects.

Box 3: Innovative winners of UN-Habitat's Best Practice Award / Scroll of Honour

- **Sam Ngaruiya**, established his company Regeneration Environmental Services to provide a community-based collection system and manufacture quality eco-construction products like traffic signs, speed bumps and street name signs. He thus provided jobs for the urban poor, while cleaning the environment and saving resources.
- **Xuzhou City, Jiangsu Province, China**, which transformed itself through the establishment of a comprehensive solid waste system, that includes the classification of waste into categories, educating its population and rewarding residents for separating garbage with points.
- **Isaac 'Kaka' Muasa**, the Chairman of Mathare Environmental Conservation Youth Group (MECYG), formed one of the earliest community-based youth groups and began collecting rubbish door to door for a fee and clearing piles of waste. MECYG has worked with a geospatial mapping organization to map resources and to build capacity in the communities.

UN-Habitat's work

One example of UN-Habitat's work connecting innovation and frontier technology in the management of waste is the "Integrated Septage Management System" in Dandora, Nairobi, which uses Internet of Things (IoT) connected sensors in pit latrines and septic tanks in the low-income settlement to remotely monitor the fill and containment of waste and septage systems. A digital platform updates residents via a text message when the septic systems require emptying. It also reviews online bids made by service providers for bulk removal of the sludge. Furthermore, the platform allows the local government to monitor and manage the appropriate removal and disposal of the waste systems. A module for tracking exhauster trucks is also planned.

The Global Expanded Monitoring Initiative (GEMI) was established by UN-Habitat, UNEP and WHO as part of the UN-Water Integrated Monitoring Initiative for Sustainable Development Goal 6 on clean water and sanitation. Together with UNECE,

UNICEF, FAO, UNESCO and WMO, existing monitoring efforts on wastewater treatment and water quality, water use and scarcity, integrated water resources management, including transboundary cooperation and water-related ecosystems, are integrated and expanded. Additionally, an expert group has been created with UNEP and international experts for the joint monitoring of solid waste related Sustainable Development Goals, namely municipal solid waste collected, and managed, hazardous waste generated and treated and national recycling rate. The developed monitoring methodology is currently being piloted jointly in Nairobi and Mombasa, Kenya.

The way forward

Frontier technologies can play a key role in innovating waste management. Examples include:

- a) Using new materials such as sustainable polymers in production to avoid waste generation or generate recyclable waste, or nanotechnology in waste treatment, harnessing its increased reactivity;
- b) 3D printing, which has the potential to generate less waste during production, as well as use “waste” as raw material;
- c) Mobile applications, logistics platforms, digital dashboards, cloud computing, big data and Internet of Things for efficient waste collection and management, as well as informed policy-making;
- d) Smart bins using artificial intelligence and/or sensors to facilitate sorting.

Innovative partnerships are for example formalizing waster pickers’ organizations’ relationships with local governments, giving them access to health care, education and other services. Furthermore, creative ideas combined with technology help reduce waste generated in the first place. The critical element is encouraging municipalities and utilities to co-create and test ideas developed for example in local incubation labs in partnership with local universities.

Turning waste into wealth in this context means using the untapped potential of waste materials:

- a) Money can be saved through rethinking what we consider waste and what we produce, refusing the production and use of single use items, reusing materials and water, reducing waste generation and recycling the unavoidable waste.
- b) As an opportunity especially for the urban poor to generate income from waste collection and treatment; frontier technologies can be used to create online accounts and enable money flows from one part of the world to the other, from high- to low-income areas.

Frontier technologies can enable city authorities to:

1. Gather accurate data on the waste flows in their city, to understand who is producing, collecting, reusing, and recycling waste and where, giving them the chance to make more informed decisions;
2. Determine the true costs of waste management and disposal including the hidden environmental and health costs;
3. Support the planning and implementation for a circular economy, i.e. moving from a linear production and consumption model to a more circular one that benefits all;
4. Improve operational efficiencies in service provision, including linking the informal and formal waste management sectors;
5. Recover valuable resources in terms of recyclables, energy, water and demand management;
6. Continuously innovate, pilot and seed solutions to improve their performance;
7. Turn waste into wealth instead of environmental and social problems, thus supporting the achievement of the 2030 Agenda for Sustainable Development.

UN-Habitat’s Strategic Plan 2020-2023

UN-Habitat’s new Strategic Plan reinforces the global agendas and has put a strong focus on sustainable waste management. Improving waste management contributes to all its four domains of change (reduced spatial inequality and poverty, enhanced shared prosperity, improved urban environment and climate action, effective urban crisis prevention and response).

Complementing the Strategic Plan, one of UN-Habitat’s five flagship projects will focus on “Frontier Technologies and Urban Innovation for Inclusive, Sustainable, Safe, Resilient and Smart Cities” – clearly reconfirming UN-Habitat’s belief in and commitment to innovation and frontier technologies.

During this year's World Habitat Day, UN-Habitat will advocate and raise awareness:

- To foster integrated waste management in the world's cities as a step towards a circular economy;
- To support the development of data collection for Waste Wise Cities;
- To facilitate the monitoring of the waste value chain together with cities and municipalities;
- To see sustainable waste management as part of the solution to achieve less poverty (SDG 1), zero hunger (SDG 2), good health and well being (SDG 3), clean water and sanitation (SDG 6), affordable and clean energy (SDG 7), decent work and economic growth (SDG 8), industry, innovation and infrastructure (SDG 9), sustainable cities and communities (SDG 11), responsible production and consumption (SDG 12), climate action (SDG 13), life below water (SDG 14) and partnerships for the Goals (SDG 17) (see Chart 1);
- To collect, review and highlight frontier technologies that can be used as innovative tools to transform waste to wealth.

... as key steps and actions necessary to work towards the global agendas, including achieving the Sustainable Development Goals, the New Urban Agenda and the Paris Agreement.

To make this happen, UN-Habitat calls on its partners and the world community:

- For local authorities:
 - To support the collection of data on sources and sinks of waste in their city;
 - To commit to integrated sustainable waste management and join the Waste Wise Cities Campaign.
- For everyone:
 - To rethink waste to change mindsets towards waste as a valuable resource;
 - To create and implement a legislative environment that envisions a circular economy;
 - To research on new frontier technologies that have the potential to substantially improve existing waste management;
 - To invest in alternative solutions to reach a circular economy.

Endnotes

- 1 UN/DESA (2018): World Economic and Social Survey 2018. Frontier technologies for sustainable development
- 2 UNCTAD (2018): Technology and Innovation Report 2018. Harnessing Frontier Technologies for Sustainable Development
- 3 This includes municipal solid waste, commercial and industrial waste, and construction and demolition waste UNEP (2015): Global Waste Management Outlook
- 4 The World Bank (2018): What a Waste 2.0. A global Snapshot of Solid Waste Management to 2050
- 5 Unites Nations World Water Assessment Programme (2017): The United Nations World Water Development Report 2017. Wastewater: The Untapped Resource
- 6 <https://wedocs.unep.org/bitstream/handle/20.500.11822/25398/WED%20Messaging%20Two-Page%202017April.pdf?sequence=12&isAllowed=true>
- 7 Estimated in the Philippines. McKinsey & Company (2016): The circular economy: moving from theory to practice
- 8 Tearfund, Fauna & Flora International, WasteAid and The Institute of Development Studies (2019): No time to waste: Tackling the plastic pollution crisis before it's too late
- 9 SDG 6.2. Access to sanitation; 6.3. Treatment, recycling and reuse of wastewater; 6.4. water-use efficiency; SDG 11.6. environmental impact of cities, including waste management; SDG 12.1. sustainable consumption; SDG 12.2. management of natural resources; 12.3. global food waste; 12.4. management of chemicals and wastes; 12.5. waste generation; and SDG 14.1. marine pollution
- 10 Intergovernmental Panel on Climate Change (2014): Climate Change 2014.Mitigation of Climate Change
- 11 Several sources including <https://archive.epa.gov/epawaste/conserve/smm/wastewise/web/html/factoid.html>
- 12 UN/DESA (2018): World Economic and Social Survey 2018. Frontier technologies for sustainable development